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Changes of distribution of thermophilous butterflies in Slovakia

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Abstract. Data from the literature and original studies concerning thermophilous butterflies and skippers (Papilionoidea and Hesperoidea) of the Pannonian region of Slovakia are presented. Endangered, vulnerable, extinct, and species with no record of permanent occurrence are discussed. Anthropogenic factors harmful to thermophilous species are analyzed, including impacts of drainage, artificial afforestation, use of chemical compounds, cattle grazing, butterfly collecting, etc. Special attention is given to the state nature reserves of south Slovakia and their lepidoptera habitats. For long term protection of thermophilous butterflies in Slovakia it will be necessary to preserve the integrity of their habitats, to reduce negative anthropogenic factors and to implement further research on the biology and population structure of these butterflies. International cooperation for their protection will be necessary as well.

Introduction

The aim of this paper is to provide information on the distribution of butterflies (Papilionoidea and Hesperoidea) across the Pannonian region of Slovakia. The region is the warmest in Slovakia. It includes lowlands, plains, basins, mountains and hills, promontories, a plateau, and highlands: Borska nizina (lowlands), Chvojnicka pahorkatina (hills), southwestern part of Biele Karpaty (mountains), southwestern and eastern parts of Myjavska pahorkatina (hills), Trnavska pahorkatina (hills), southern and low-lying parts of Male Karpaty (mountains), Podunajska rovina (plain), the southernmost part of Povazsky Inovec (mountains), Nitrianska pahorkatina (hills), Hornonitrianska kotlina (basin), Zitavska pahorkatina (hills), the southernmost part of Tribec (mountains), Hronska pahorkatina (hills), Ipelska pahorkatina (hills), southern part of Krupinska planina (plateau), Ipelska kotlina (basin), Lucenska kotlina (basin), Cerova vrchovina (highlands), Rimavska kotlina (basin), Bodvianska pahorkatina (hills), Slovensky kras (plateau), Roznavska kotlina (basin), Kosicka kotlina (basin), southern part of the Slanske vrchy (highland), Vychodoslovenska pahorkatina (hills), southern part of the Ondavska vrchovina (highlands), Beskydske predhorie (promontory), Zemplinske vrchy (highlands), and Vychodoslovenska rovina (plain). The overall area is mapped as Fig. 1.

Fig. 1 Map of the Pannonian region of Slovakia.

Publications concerned with butterflies of the Pannonian region

Earlier faunistic data on butterflies from the Pannonian region are summarized in Prodromus Lepidopter Slovenska (Hruby, 1964). Since publication of this work, faunistic research has progressed, but several territories of the Pannonian region are still not well understood faunistically. The Male Karpaty and nearby hills belong to the best explored regions of western Slovakia. These regions were studied by several lepidopterologists including Caputa (1968a, b, 1970) who described the butterfly fauna of the state nature reserve, Devinska Kobyla; M. Kulfan (1982) who published the distribution of butterflies from the northern part of the Male Karpaty and Myjavska pahorkatina; and J. Kulfan (1990) who investigated communities of butterflies in the southern part of the Male Karpaty.

Rysavy (1984) and J. Kulfan (1990) studied the lowland butterfly communities of Borska nizina while the warmest Slovakian mountain region, Kovacovske kopce (Burda) and nearby territory was explored by Moucha (1959, 1961), Degma *et al.* (1984) and Caputa (1987)..Other authors presenting faunistic data from the Pannonian region of west Slovakia included Kristof (1973), Kubanik (1979), Madlen (1971, 1974, 1975, 1976) and Sachl (1980).

A few publications refer to studies of the smallest part of the Pannonian region located across central Slovakia (e.g., Caputa, 1963; Skypala, 1978; J. Kulfan, 1989). There are many references to the butterfly fauna of the Pannonian region of east Slovakia, however (e.g., Brunnerova *et al.* , 1984; Caputa , 1960; Ceplik, 1976; Panigaj, 1983; Vacula, 1975;

Vacula *et al.*, 1971; Vacula and Vahala, 1973; Zuskinova, 1971; Lastuvka, 1988). In addition Caputa (1960) and Lastuvka (1988) explored butterfly communities in the largest Slovakian karst, Slovensky kras (Zadiel, Plesivecka planina plateau).

The occurrence of individual species were reported by Kulfan *et al.*, 1986; Stiova, 1976; Svestka, 1979; Zelny, 1961 and others. Migratory species in the Pannonian region have been reported by Moucha, Slimak, Cerny, Jakes, Lastuvka, Pipek, Cervinka, Kirnig, M. Kulfan and Gottwald (in Moucha, 1965; Felix, 1971; Felix and Soldat, 1972; Felix *et al.*, 1978; Pipek and Soldat, 1979, 1980).

Development of the ecosystems of the Pannonian region

The Pannonian region can be characterized as mixed deciduous woods which represent both the original and climax communities. During the past 12,000 years, however, natural undisturbed vegetation processes came to an end. Extensive forest clearance took place as the landscape was colonized by Neolithic farmers. Forest areas were transformed into derived meadow, pasture, and crop ecosystems which subsequently gave rise locally to secondary forest ecosystems. As a result, there were corresponding changes in the climate and in hydrology as the forest soils were converted to agricultural land. Consequently, conditions evolved which promoted the development of new vegetation types and landscapes. These new ecosystems were formed from adaptable elements of the forest flora, by relict taxa that survived in extreme sites (as on blown sand, flood plains, saline soil, peat bogs, and rocks), and finally by a series of exotic species introduced by the early agricultural peoples (Rybnicek and Rybnickova, 1986). From 7,000 to 5,000 YBP Neolithic farmers settled into and transformed the hill areas of southwestern and southeastern Slovakia. About 3,000 YBP there was a gradual occupation and deforestation of the submontane areas and the broad valleys of large rivers.

During the Late Glacial period of 12,000 to 10,000 YBP, the southern part of Slovakia was covered by forest-steppe and steppes of more or less continental character. Pine and birch were the prevalent timber species but some more demanding species were present also including oak and elm. The alluvia of large rivers were covered extensively with aquatic and swamp vegetation along with willow stands.

During the Early Holocene (Boreal) of 10,000 to 8,000 YBP, the region was already covered by an open forest of pine, birch, elm and oak, with an undergrowth of hazel and other shrubs and with a well developed herbaceous layer. Earlier willow stands were gradually replaced by floodplain, so since the end of the Boreal period, there were alder woods with birch and possibly some oak. During the early Atlantic period (8,000 YBP), the forested landscape gradually began a transformation to an agricultural land. Since that time there has been a general contraction of forest stands and a concomitant increase of fields, meadows and

pastures. Remnants of the woods that were the original open thermophilous oak and mesophilous oak forest were replaced by hornbeam oak woods, at first with oaks and elms dominant, and later during early Holocene with hornbeam.

On poor sandy soil, e.g., the Zahorie region, oak-pine woods dominated. Since the Atlantic period, but especially since the sub-Boreal, a secondary steppe-like vegetation evolved. Alluvial portions of the Podunajska rovina and Vychodoslovenska rovina plains were covered by floodplain woods since mid-Holocene. These landscapes were similar in appearance to those of the present day, containing alder, willows, poplars, oaks, elms, ash, and later hornbeam. Alders and willows prevailed in smaller river valleys (Rybnicek and Rybnickova, 1986).

Before man intervened by converting the vegetation across this country 6,000-7,000 YBP, forest covered about 90% of the area. By the 14th century about 60% of Slovakia was covered by forests. Pines and exotic tree species were extensively planted on deteriorated and stony soils. In vineyard areas the spread of the black locust, *Robinia pseudoacacia* L., was encouraged, as this exotic plant was important for bee culture while providing good timber for wheel making and firewood. In recent years black locust monoculture has expanded in the southern part of south Slovakia and now covers more than 50% of forest area in many places.

Butterfly fauna of the Pannonian region

The Appendix lists all the species found in the Pannonian region. The list shows that 165 species of butterflies historically occurred in the Pannonian region, of which 148 species are probably still present. Forty six Slovakian species of butterflies occur chiefly in the Pannonian region. The following species are characteristic of this region, but also occur in the warm sites of the mountains of West Carpathia (Zapadne Karpaty mountains): *Pyrgus serratulae, P. sertorius, I. podalirius, Papilio machaon, Colias alfacariensis, Leptidea morsei, Aricia agestis, Callophrys rubi, Glaucopsyche alexis, Maculinea arion, Nordmannia pruni, N. spini, Polyommatus bellargus, P. coridon, P. daphnis, P. dorylas, Scolitantides orion, Chazara briseis, Hipparchia semele, Melitaea aurelia,* and *M. didyma.*

Species of special significance.

ENDANGERED AND VULNERABLE SPECIES OF XEROTHERMIC SITES, MEADOWS AND DAMP BIOTOPES.

Carcharodus flocciferus, Pyrgus armoricanus, Colias chrysotheme, Glaucopsyche alexis, Lycaena thersamon, Maculinea arion, Polyommatus admetus, P. amandus, P. bellargus, P. damon, P. daphnis, P. eroides, Pseudophilotes schiffermuelleri, Scolitantides orion, Melitaea aurelia, M. britomartis, M. fascelis and M. phoebe are species which inhabit xerothermic biotopes. They are all endangered, chiefly by afforestation,

fires, natural forest and shrubs succession, agricultural conversion with increasing areas of vineyards, gardens and orchards, waste disposal sites, cattle and sheep grazing with consequent affect on erosion, plant community composition, and application of insecticides and herbicides in the vicinity of agricultural areas. These are also sites which are considered to be soils without practical use. Such sites are used for building and for sports, as motocross. Some of these species are moving to secondary sites formed by man, as railway embankments and road cuts. Generally, conservation of butterfly species cited is positively influenced by extensive grazing because continuous shrub and tree stands are reduced.

Nordmannia acaciae, N. pruni, N. spini and *Thecla betulae* occur in similar sites but require the presence of woody plants at the proper growth stage which are the optimal foodplants of their larvae.

Euphydryas maturna is now present in only a few populations in the Pannonian region. Besides the harmful anthropogenic factors discussed, the species is endangered by both overcollecting and by changes in forestry management. The causes of the rapid decline of *Lasiommata achine* are not clear over the last decades. *Nordmannia w-album* is endangered through change in timber composition in the forest ecosystem.

Neptis sappho occurred regularly at many localities a few decades ago. The causes of its decline are not clear.

Hipparchia hermione, known in the Central European literature as *H. alcyone* or *H. aelia*, and *H. statilinus* are inhabitants of sandy biotopes as the Broska nizina lowland and in the sand dune grasslands of the southernmost part of Slovakia. Preservation of these sandy biotopes in their present state is necessary for their long term survival.

Colias myrmidone and *Brenthis hecate* are represented by some isolated populations in the Pannonian region. The two species occur both in xerothermic biotopes and mesophilous and wet meadows. Relatively dense populations of these species occur in the southwestern part of Biele Karpaty mountains in extensively managed meadows which are mowed once a year. Both species are now endangered by changes of meadow management including fertilization, cattle and sheep grazing, and ploughing.

Aricia eumedon, Lycaena alciphron, Maculinea alcon, M. nausithous, M. teleius, Coenonympha tullia, Brenthis ino, Euphydryas aurinia and *Melitaea diamina* are inhabitants of wet meadow biotopes. They are highly endangered through changes of meadow management and wetland drainage.

Lycaena dispar is endangered where it occurs on xerothermic sites near wet biotopes as in the Male Karpaty mountains and Cachtice hills.

Neptis rivularis occurs as a local riparian species along streams chiefly in inaccessible places. It will be endangered by construction of thoroughfares and the artificial embankment of natural watercourses.

Parnassius mnemosyne occurs chiefly in forest-steppe biotopes in the Pannonian region. The ecological situation is unlike that in mountain biotopes where the species prefers forest meadows and glades. The principles of conservation cited above for xerothermic species are valid for *P. mnemosyne.* Its isolated and small populations are highly vulnerable to overcollecting.

Zerynthia polyxena is a characteristic species of the Pannonian region, occurring near vineyards, along railways and roads, and near streams. There are numerous populations of *Z. polyxena*, especially in the region of the Podunajska rovina plain and the Borska nizina lowland near large streams. The many isolated populations are chiefly endangered along the northern border of the Pannonian region by vegetation burning on road and railway embankments, application of insecticides and pesticides, repairs along the thoroughfares, and collection of both adults and larvae.

INDETERMINATE SPECIES.

Pyrgus serratulae, Spialia orbifer, Leptidea morsei, Pieris mannii, Aricia allous, Cupido alcetas, C. osiris, Lycaeides idas, Maculinea rebeli and *Polyommatus thersites* are indeterminate species, species which are probably endangered in the Pannonian region. Their distribution is insufficiently known because they all can be confused easily with commonplace species at sites where butterfly communities are dense.

There is insufficient information concerning *Thymelicus acteon.* This species is easily overlooked by collectors.

Limenitis reducta often escapes recording because collecting voucher specimens is not easy. It may also be mistaken for *L. camilla* during flight.

PROBLEMATIC SPECIES.

There are 17 species of problematic occurrence in the Pannonian region at present. Information on their occurrence arises chiefly from very old records: *Carcharodus lavatherae, Parnassius apollo, Colias palaeno, Cupido osiris, Iolana iolas, Lampides boeticus, Lycaena helle, Syntarucus pirithous, Vacciniina optilete, Coenonympha hero, C. oedippus, Pyronia tithonus, Argynnis pandora, Boloria aquilonaris, B. eunomia, B. titania,* and *Nymphalis l-album.*

In the recent past populations of *Parnassius apollo* were probably present on promontories of the west Carpathians. At present this species is not known even in the vicinity of Slovensky kras plateau (Lastuvka, 1988). Many populations of this species have disappeared across all of Europe as the result of the conversion of biotopes.

It appears that *Argynnis pandora* is no longer present in Slovakia. The species occurred frequently at many localities of south Slovakia as recently as a few decades ago. In past years *Nymphalis l-album* and *N. xanthomelas* were observed, but only sporadically. *N. xanthomelas* was

found in the Kovacovske kopce hills about 10 years ago (Caputa, 1987), and probably still occurs in south Slovakia. Long term climatic changes may well become a major cause of extinction of these species in the near future.

The butterfly fauna of the Pannonian region may be sporadically augmented by migrants from the south. *Lampides boeticus* and *Sytarucus pirithous* appear sporadically in the Pannonian region. *Colias crocea* appears very frequently and can be classified as an abundant species in many years.

Colias erate first appeared in Slovakia in 1989 near the town Nove Zamky (Petru and Bohm, in press). In 1990 it was found at many localities of the Pannonian region, near Sturovo, Komarno, Piestany, Nove Mesto n. Vah (J. Marek, M. Svestka, L. Vitaz and J. Patocka, pers. comm.). Females were observed laying eggs and fresh adults were observed which clearly indicate the species can permanently breed in the Pannonian region. Adults of *C. erate* were observed across the same biotopes as *Colias crocea.* We cannot predict whether *C erate* will be permanently established in the Pannonian in the future. Its appearance may be an indicator of long term climatic change, although the possibility of adaptive change within the species' genetic system may explain this new distribution.

Very recently *Heteropterus morpheus* and *Cupido decoloratus* have expanded their ranges across the Pannonian region. Both species were local and rare in the past. For example, *Heteropterus morpheus* was not recorded from the state nature reserve Devinska Kobyla, near Bratislava, in the 1960s (Caputa, 1970). At present it occurs regularly at this locality. It is also known from many localities of southwestern Slovakia (Reiprich and Okali, 1989; J. Kulfan, 1990). *Cupido decoloratus* occurs at many localities of southern Slovakia along streams in the north (M. Kulfan, 1982; Kulfan *et al.*, 1986; J. Kulfan, 1989, 1990; Reiprich and Okali, 1989).

Conservation of biotopes

Protection of butterflies in the Pannonian region is not a simple matter, mainly because the region contains mostly intensively utilized agricultural land. Consequently, most meaningful conservation efforts for the butterfly fauna can be carried out in the hills and the mountain slopes. Butterflies which occur across the narrow zones of forest-steppe vegetation between vineyards and forest stands, as in the Male Karpaty and Tribec mountains, Krupinska planina plateau and Kovacovske kopce hills, are now endangered by intensive viticulture with predictable total extirpation. The biotopes of Borska nizina lowlands represent sand dunes grasslands which are changing not only by intensive agriculture but also by continuous afforestation, both natural and artificial, and by construction of tourist cabins and holiday homes.

There are damp biotopes of relatively large areas in the Borska nizina

lowlands, many situated in the borderland near Austria. This territory was inaccessible until a year ago. The land has now been intensively utilized for agriculture, and wetland drainage will cause destruction of these biotopes. Chemical application for mosquito control compounds the problem of survival of this specialized butterfly fauna.

There are local saline soils in some places of south Slovakia, but the remaining biotopes of these sites are isolated. No lepidopterological research has been completed on these biotopes.

The spread of the introduced alien black locust, *Robinia pseudoacacia,* has a very negative effect on the natural Pannonian vegetation. As a legume it also modifies soil chemistry by increasing nitrogen levels in the soil.

In light of the massive negative anthropogenic influences across a substantial part of the region, state nature reserves and some preserved landscape zones are now vital for the conservation of the butterfly fauna. Too few reserves occur in the Pannonian region at the present time, and they are often isolated without connections that can increase metapopulation survival. In the future it will be necessary to form a network of the reserves as well as a network of zones without intensive agriculture. Only in such manner can reserves be interconnected, and long term persistence of habitat values maintained.

Another management technique for the conservation of biotope diversity would be necessary: short term extensive grazing and planned mowing and burning. For instance, today there is extensive sheep grazing on forest-steppe biotopes on the Hainburg Bergen in Austria near the state nature reserve Devinska Kobyla in Male Karpaty mountains. Here the spread of undesirable herbs, shrubs and trees is reduced by sheep grazing. In addition, across some smaller areas weed burning is employed. Similar management techniques are planned for the state nature reserve Devinska Kobyla. All these methods increase floral diversity and will positively impact butterfly survival.

Flowery meadows can be mowed, most appropriately during two periods, each on half the land area, so that butterflies could move from the mowed section to the unmowed one.

State nature reserves in the Pannonian region possess a rich butterfly fauna. For example, in S. N. R. Devinska Kobyla (Caputa, 1970; M. Kulfan, collection) S. N. R. Kovacovske kopce hills (Hruby, 1964; Reiprich, 1977; Caputa, 1987) and S. N. R. Cachticke hradny vrch and its near vicinity (M. Kulfan, 1982; Reiprich and Okali, 1989; M. Kulfan, collection; Vitaz, pers. comm.), respectively 80, 116 and 101 species have been recorded. A rich community of butterflies, including 31 species of Lycaenidae, are concentrated on a small area in Cachticke kopce hills (Male Karpaty mountains) (M. Kulfan, 1982; M. Kulfan, collection). Therefore the Cachticke kopce hills can be identified as a butterfly reservation containing both xerothermic and wet biotopes.

The greatest number of butterfly species occurs across the Plesivecka planina plateau. This is part of a preserved landscape area, Slovensky

kras plateau. Prior to 1988 121 species of butterflies occurred here (Hruby, 1964; Lastuvka, 1988; Reiprich and Okali, 1989).

For protection of a thermophilus butterfly fauna in Slovakia, it will be necessary to considerably increase our knowledge of their population dynamics and ecology. In addition comprehensive inventories of many present reserves do not exist. However, research must rapidly be directed not only to the preserved areas, including the monitoring of selected indicator species with estimates of population sizes, but also extended to the regions which should be preserved for the future. In other countries of central and south Europe there are biotopes that are related to those in the Pannonian region of Slovakia and international cooperation relating to the preservation of butterflies of these sites should begin.

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Appendix. Species found in the Pannonian region

Hesperiidae

Carcharodus alceae ■○●
C.flocciferus ■○●V
C. lavatherae ■○?
C. palaemon ○●
Erynnis tages ○●
Hesperia comma ○●
Heteropterus morpheus ■○●
Ochlodes venatus ○●
Pyrgus alveus ○●□
P. armoricanus ■○●V
P. carthami ■○●
P. malvae ○●
P. serratulae ○●I
Spialia orbifer ■○●I
S. sertorius ○●
Thymelicus acteon ■○●I
T. flavus ○●
T. lineolus ○●

Papilionidae

Iphiclides podalirius ★○●
Papilio machaon ★○●
Parnassius apollo ★○◆E?□
P. mnemosyne ★○●◆V
Zerynthia polyxena ★■○●◆V

Pieridae

Anthocharis cardamines ○●
Aporia crataegi ○●
Colias alfacariensis ○●
C. chrysotheme ■○●E
C. crocea ○●◗
C. erate ■●I◗
C. hyale ○●
C. myrmidone ■○●E
C. palaeno ○◆E?
Gonepteryx rhamni ○●
Leptidea morsei ○●I
L. sinapis ○●
Pieris brassicae ○●
P. bryoniae ○●□
P. daplidice ○●
P. mannii ■○●I
P. napi ○●
P. rapae ○●

Lycaenidae

Aricia agestis ○●
A. allous ■●I
A. eumedon ○●◆E
Callophrys rubi ○●
Celastrina argiolus ○●
Cupido alcetas ■○●I
C. argiades ○●
C. decoloratus ■○●
C. minimus ○●
C. osiris ●I?□
Cyaniris semiargus ○●
Glaucopsyche alexis ○●◆E
Iolana iolas ○●?
Lampides boeticus ○?◗
Lycaeides argyrognomon ■○●
L. idas ■○●I
Lycaena alciphron ○●E
L. dispar ■○●◆E

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